US010529640B2

(12) **United States Patent**
Kwak et al.

(10) **Patent No.: US 10,529,640 B2**
(45) **Date of Patent: Jan. 7, 2020**

(54) **APPARATUS FOR MANUFACTURING A THERMOELECTRIC MODULE**

(71) Applicants: **Hyundai Motor Company**, Seoul (KR); **Kia Motors Corporation**, Seoul (KR)

(72) Inventors: **Jin Woo Kwak**, Gyeongsan-si (KR); **Kyong Hwa Song**, Seoul (KR); **Byung Wook Kim**, Seongnam-si (KR); **In Woong Lyo**, Suwon-si (KR); **Han Saem Lee**, Seoul (KR)

(73) Assignees: **Hyundai Motor Company**, Seoul (KR); **Kia Motors Corporation**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 191 days.

(21) Appl. No.: **15/714,450**

(22) Filed: **Sep. 25, 2017**

(65) **Prior Publication Data**

US 2018/0122719 A1 May 3, 2018

(30) **Foreign Application Priority Data**

Oct. 27, 2016 (KR) 10-2016-0141155

(51) **Int. Cl.**
B23P 19/00 (2006.01)
H01L 23/34 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01L 23/345*** (2013.01); ***H01L 23/5328*** (2013.01); ***H01L 29/401*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC . H01L 23/345; H01L 23/5328; H01L 29/401; H01L 35/22; H01L 35/30; H01L 35/32; H01L 35/34
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,643,663 A * 2/1987 Bowles B29C 43/04 425/406
6,399,918 B1 * 6/2002 Komine B29C 43/18 100/295

(Continued)

FOREIGN PATENT DOCUMENTS

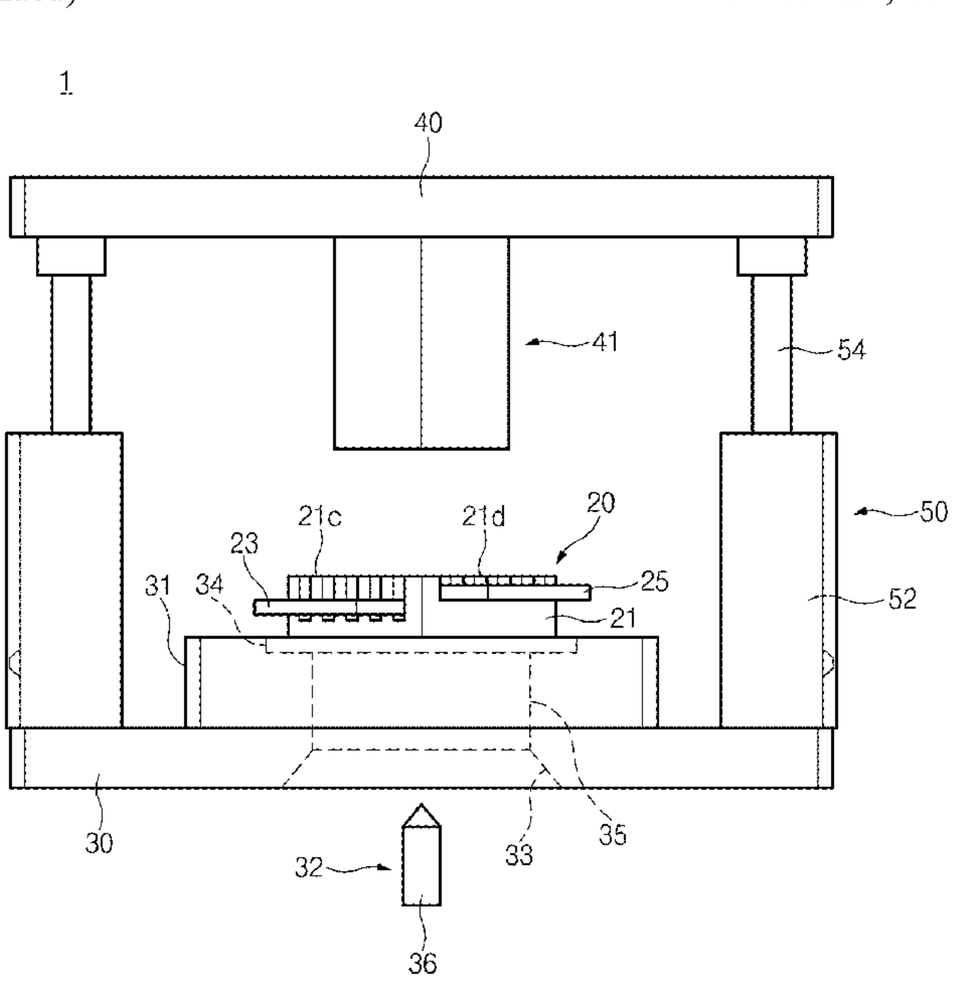
JP 2006278385 A 10/2006
KR 101184155 B1 9/2012

Primary Examiner — Paul D Kim
(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

(57) **ABSTRACT**

An apparatus for manufacturing a thermoelectric module is provided. The thermoelectric module includes thermoelectric pellets, first electrodes, second electrodes, and an insulating substrate. The apparatus includes a fixing tray to which the thermoelectric module is fixed, a first die including a first heating member configured to heat a first adhesive layer, which is interposed between the thermoelectric pellets and the first electrodes. The fixing tray is mounted on the first die such that the insulating substrate faces the first heating member. A second die includes a second heating member configured to heat a second adhesive layer, which is interposed between the thermoelectric pellets and the second electrodes, the second die facing the second electrodes. A transfer unit is configured to transfer at least one of the first die and the second die to adjust a distance between the first die and the second die.

20 Claims, 11 Drawing Sheets



(51) **Int. Cl.**

H01L 23/532	(2006.01)
H01L 29/40	(2006.01)
H01L 35/22	(2006.01)
H01L 35/30	(2006.01)
H01L 35/32	(2006.01)
H01L 35/34	(2006.01)

(52) **U.S. Cl.**
CPC ***H01L 35/22*** (2013.01); ***H01L 35/30*** (2013.01); ***H01L 35/32*** (2013.01); ***H01L 35/34*** (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,911,606	B2 *	6/2005	Suda	H01L 21/563 174/259
2010/0024667	A1	2/2010	Ikura	
2014/0219854	A1 *	8/2014	Matsen	B22F 3/16 419/29
2019/0051808	A1 *	2/2019	Larsson	H01L 35/18

* cited by examiner

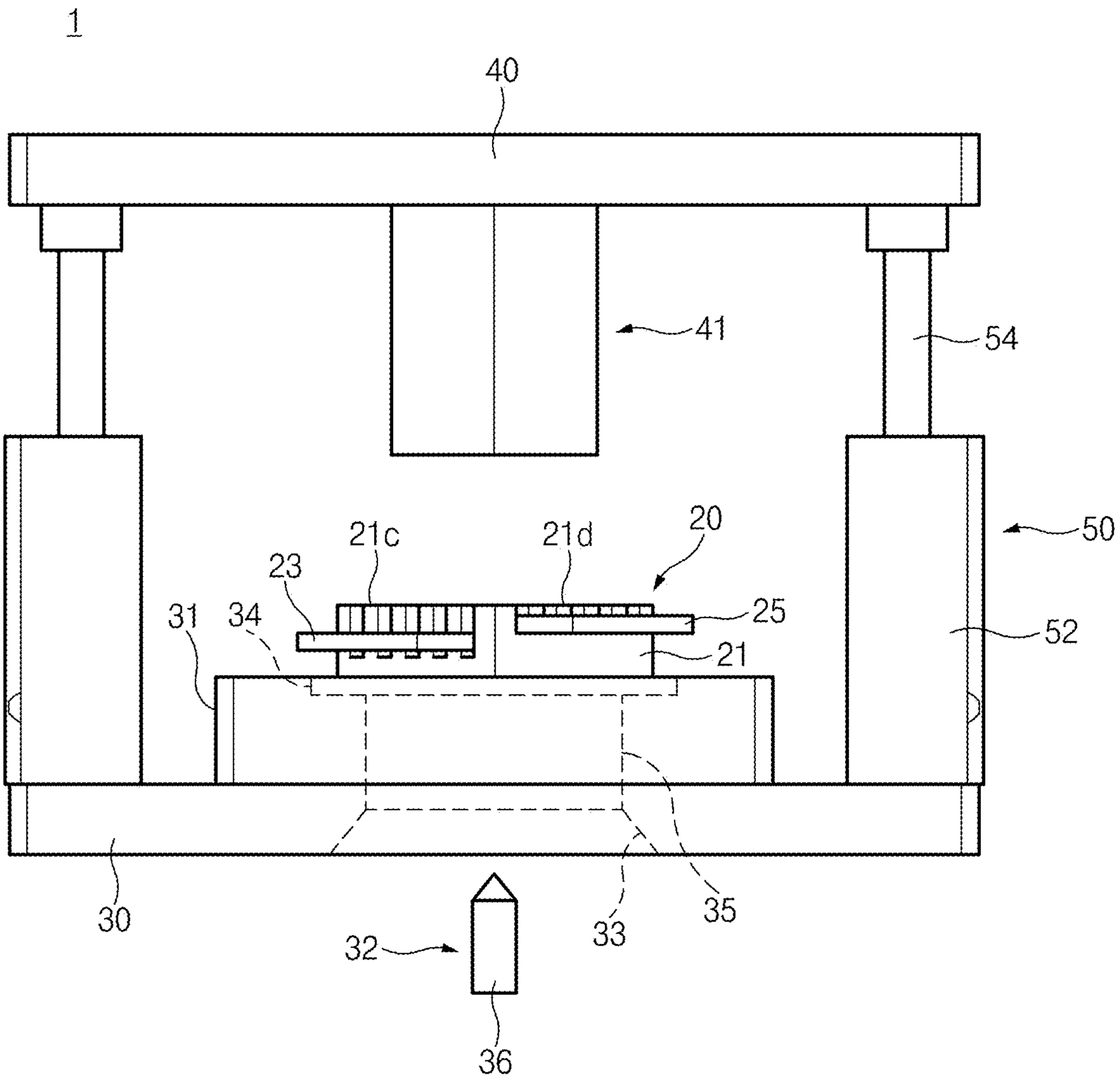


FIG.1

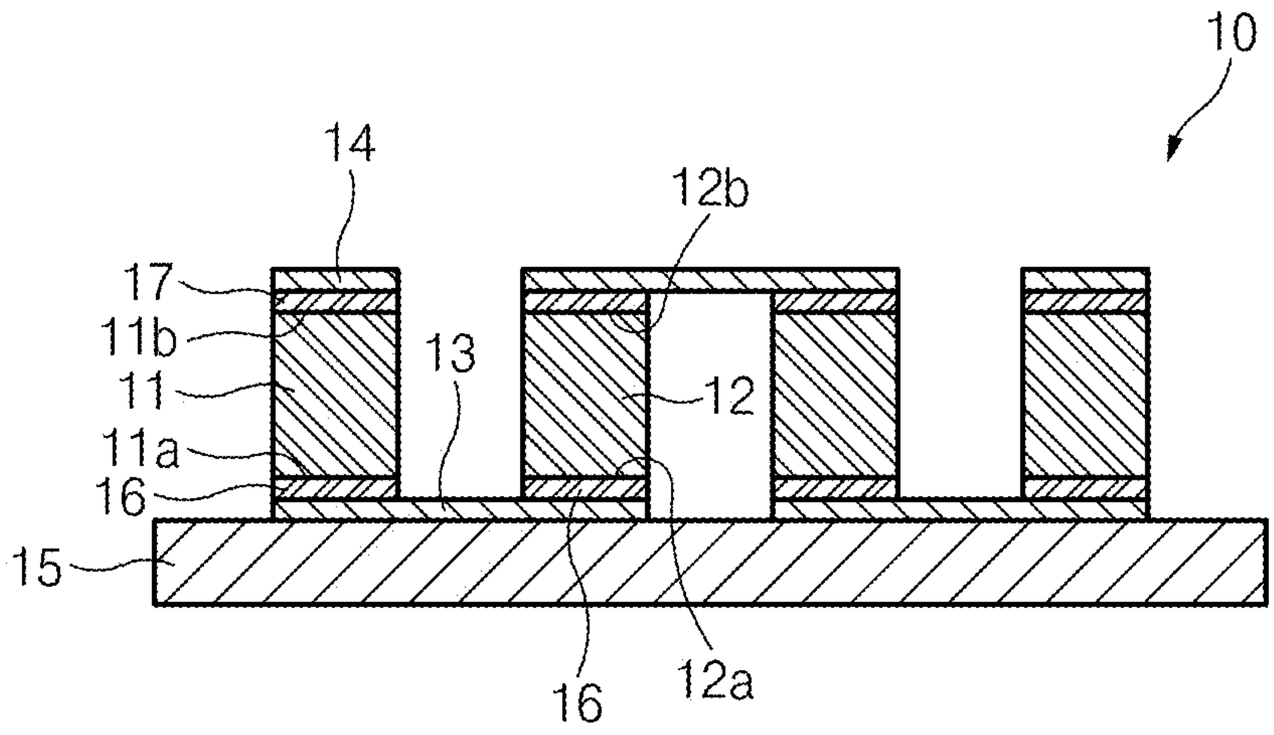


FIG.2

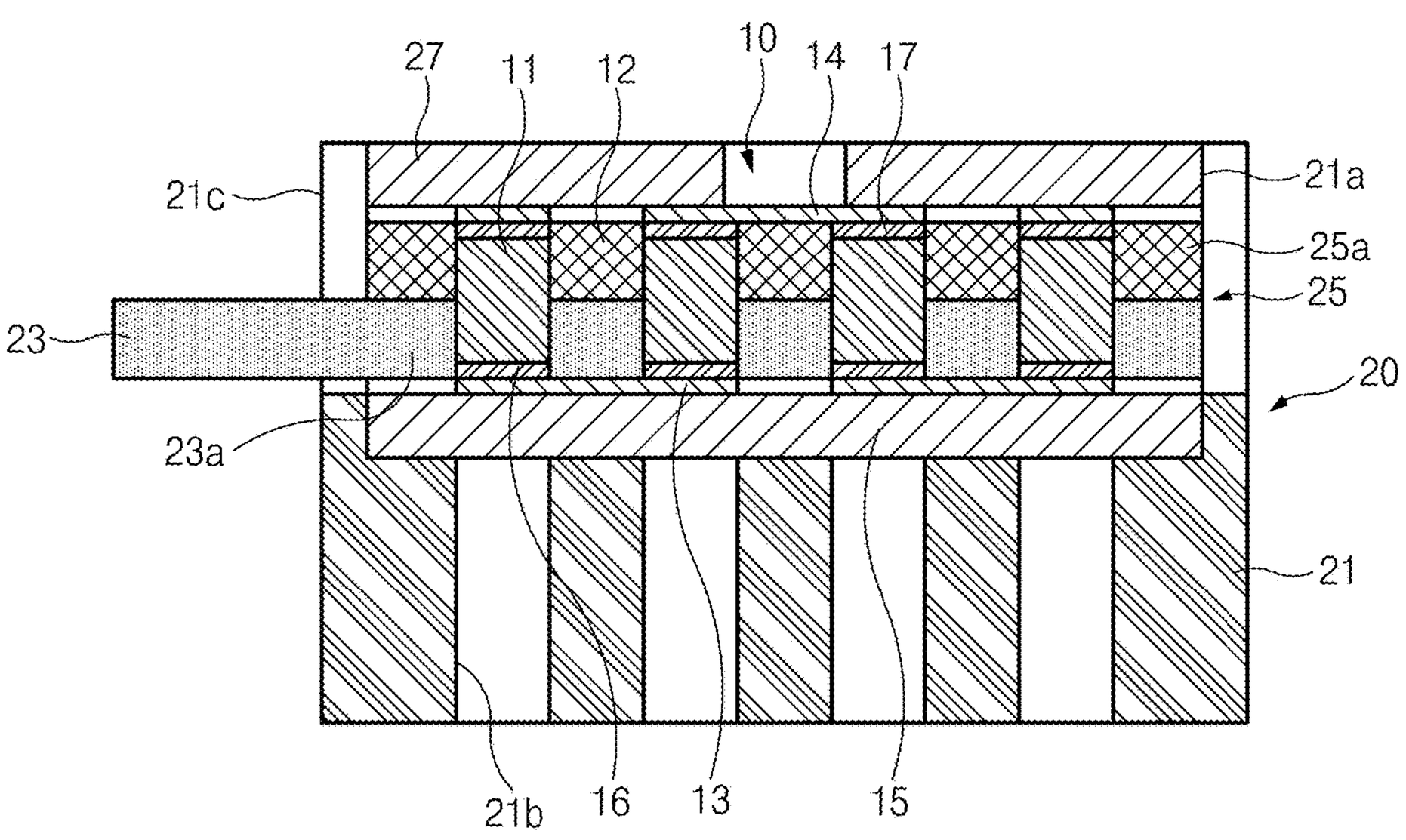


FIG.3

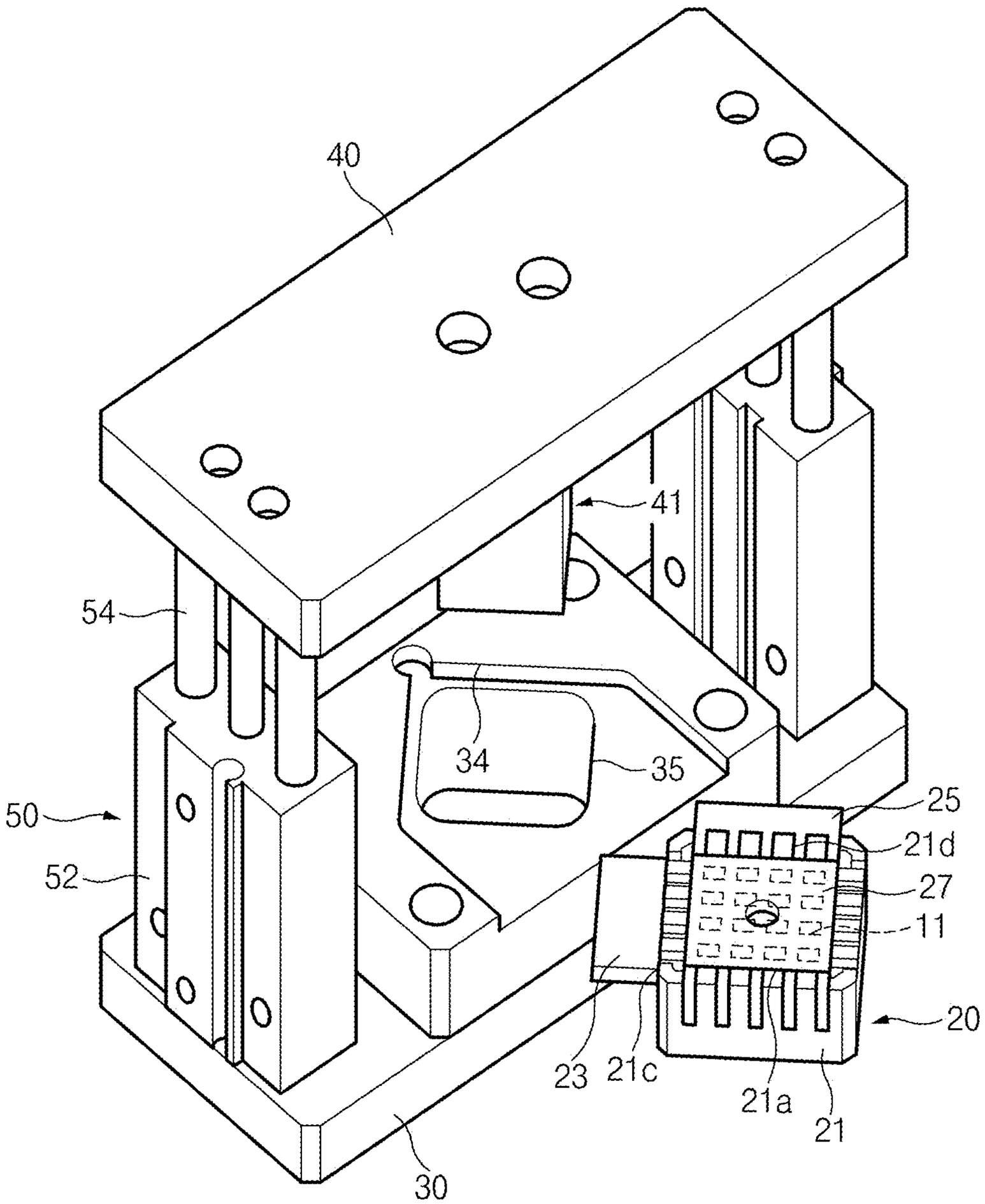


FIG.4

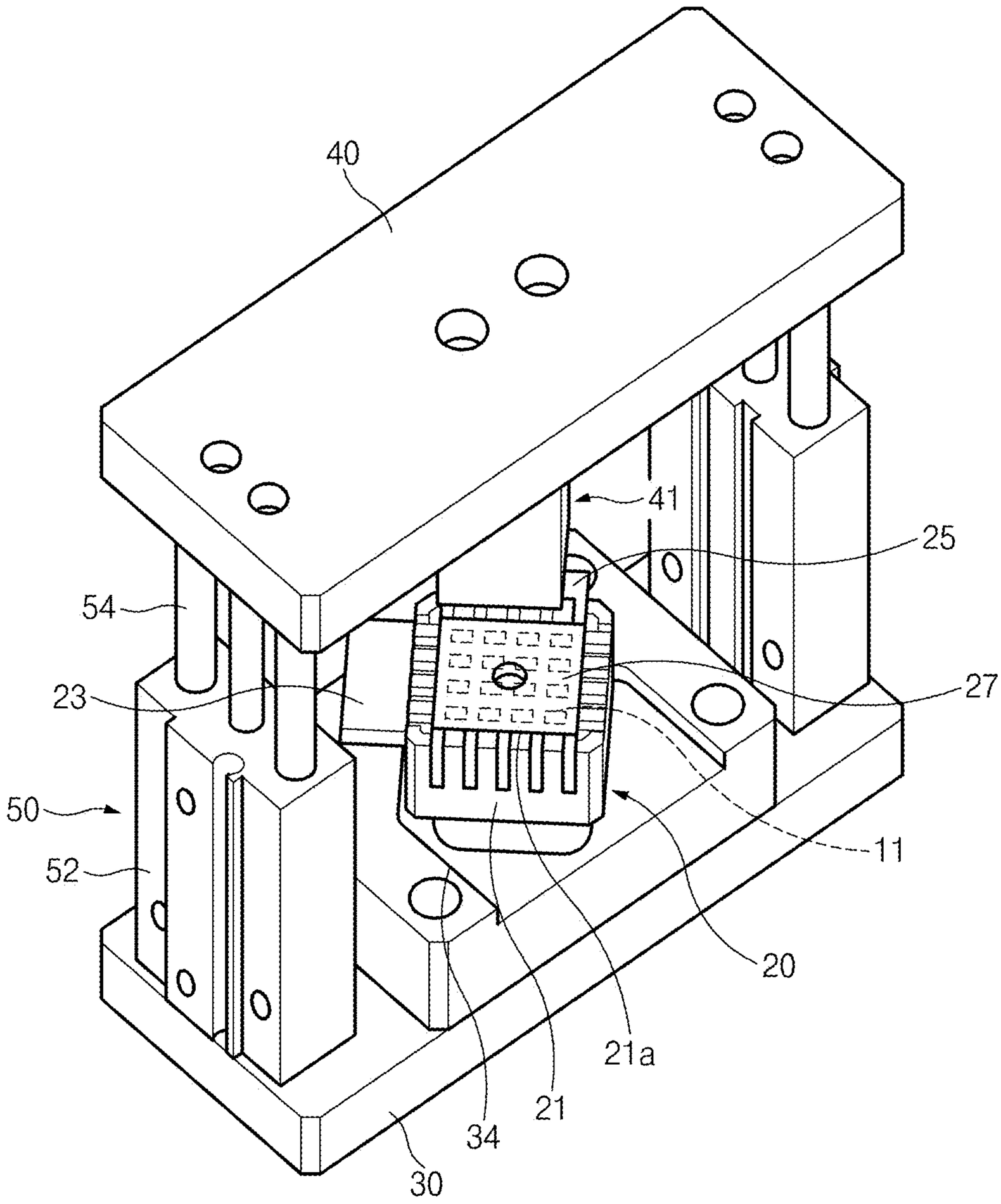


FIG.5

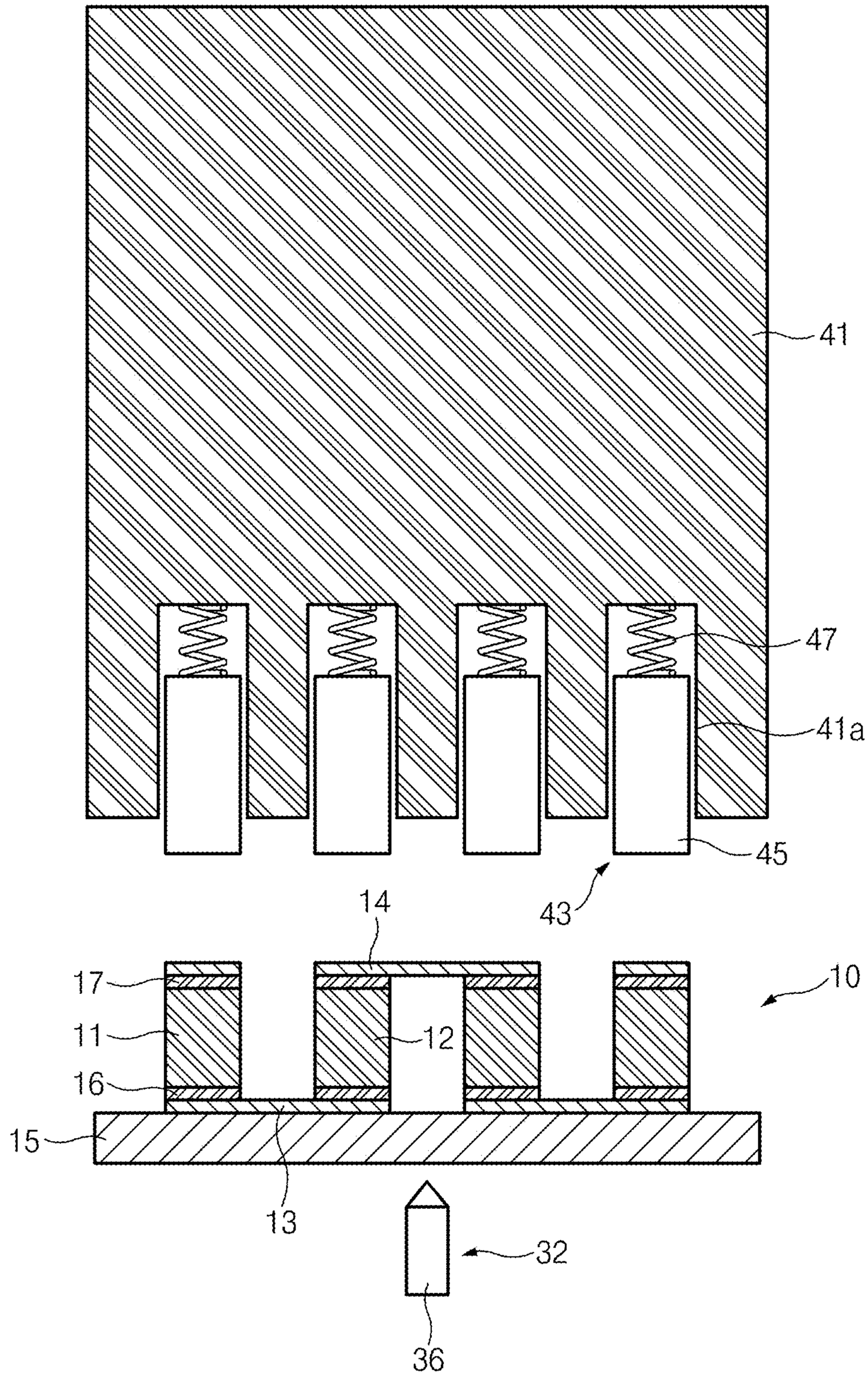


FIG.6

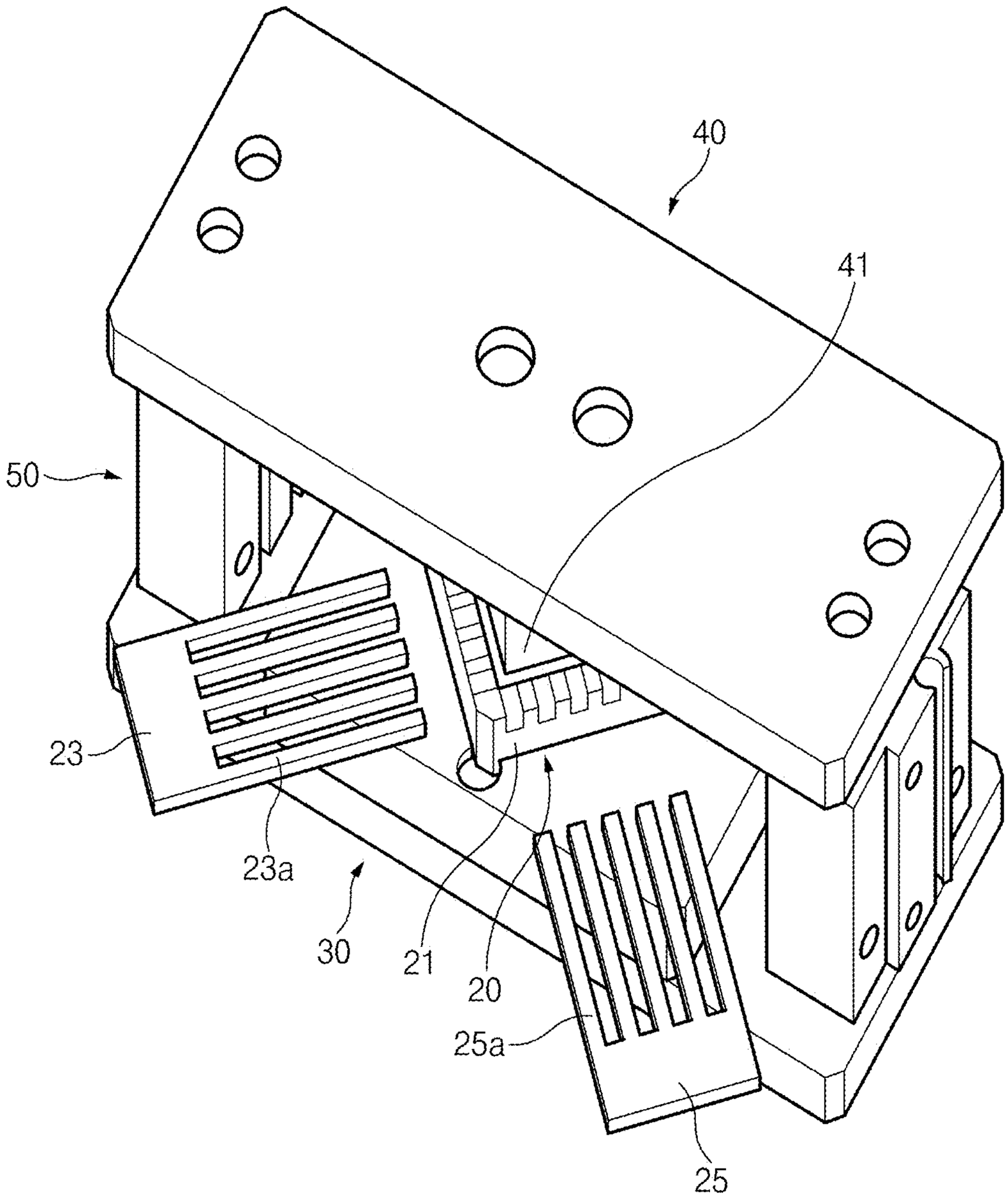


FIG.7

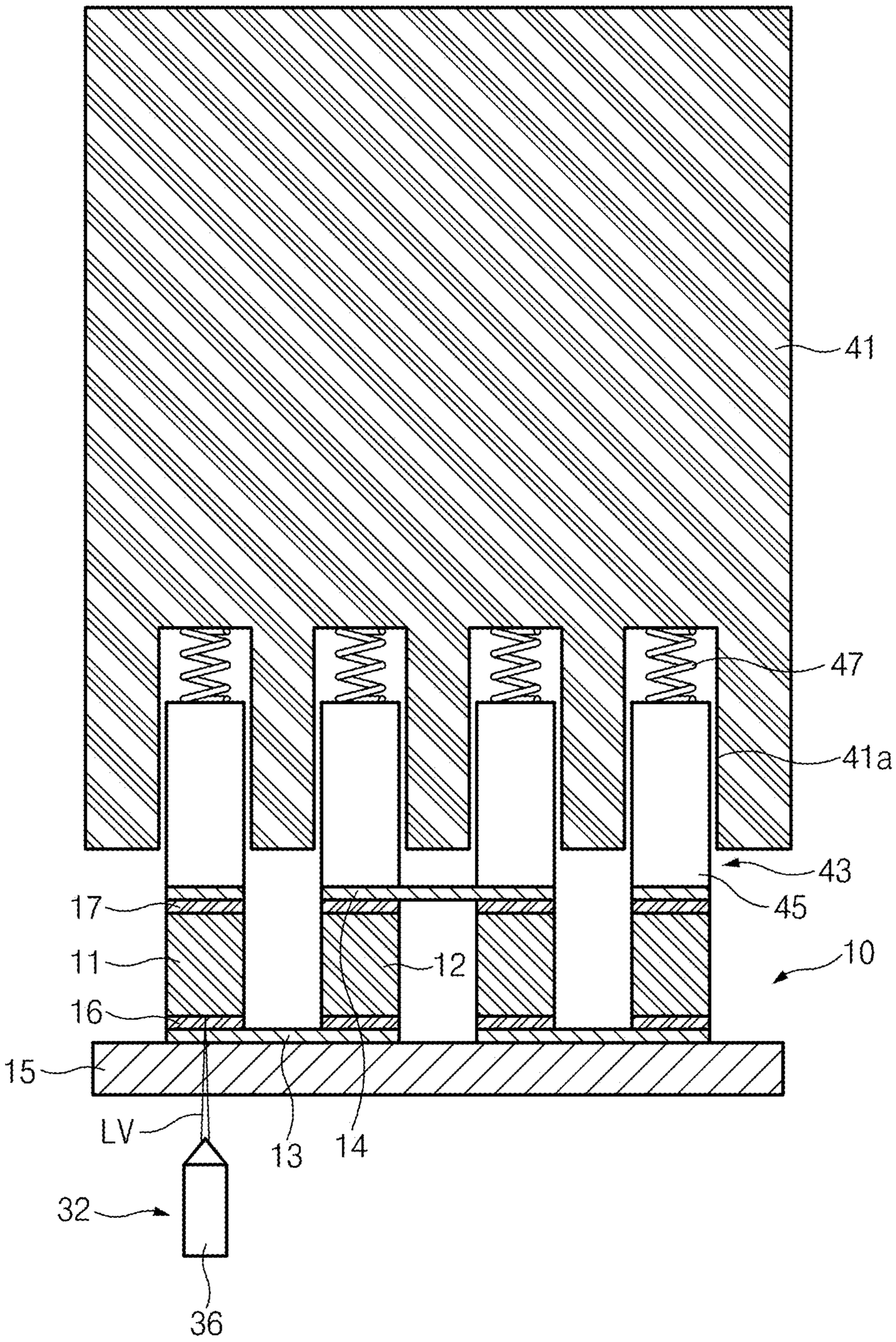


FIG.8

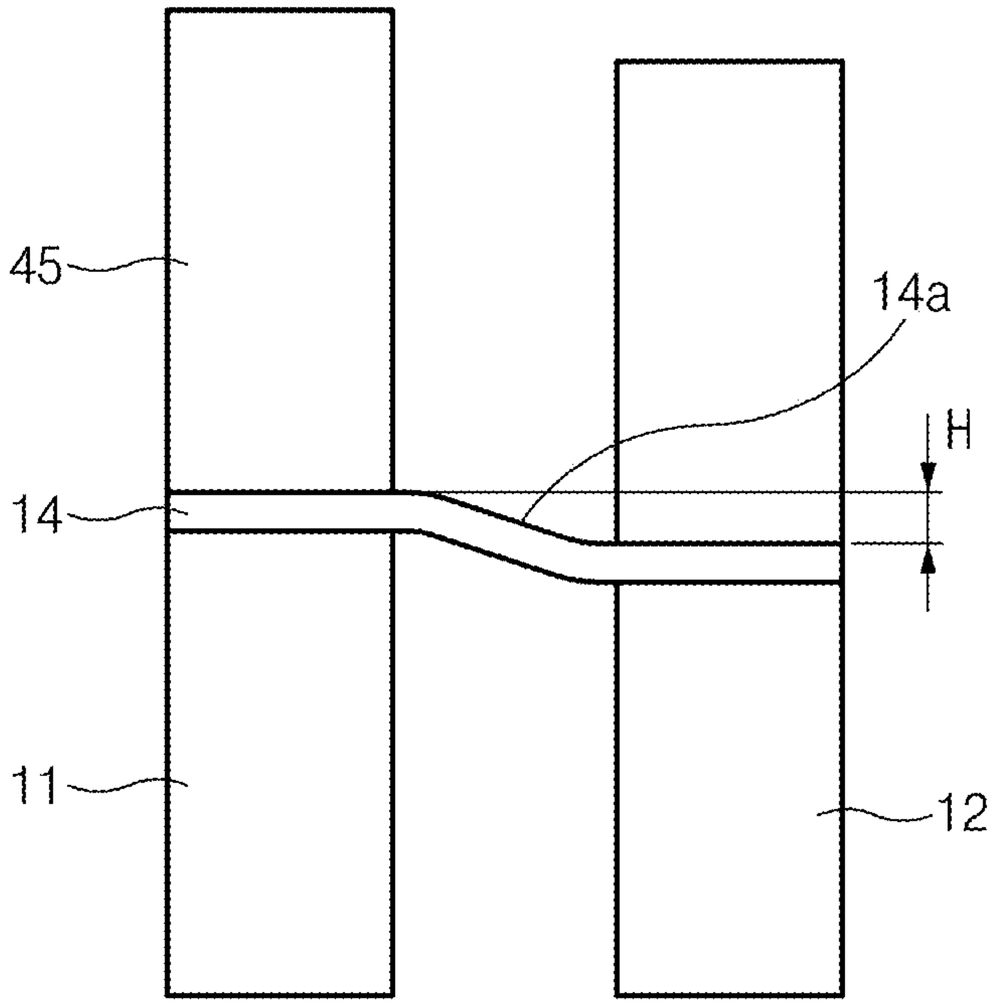


FIG.9

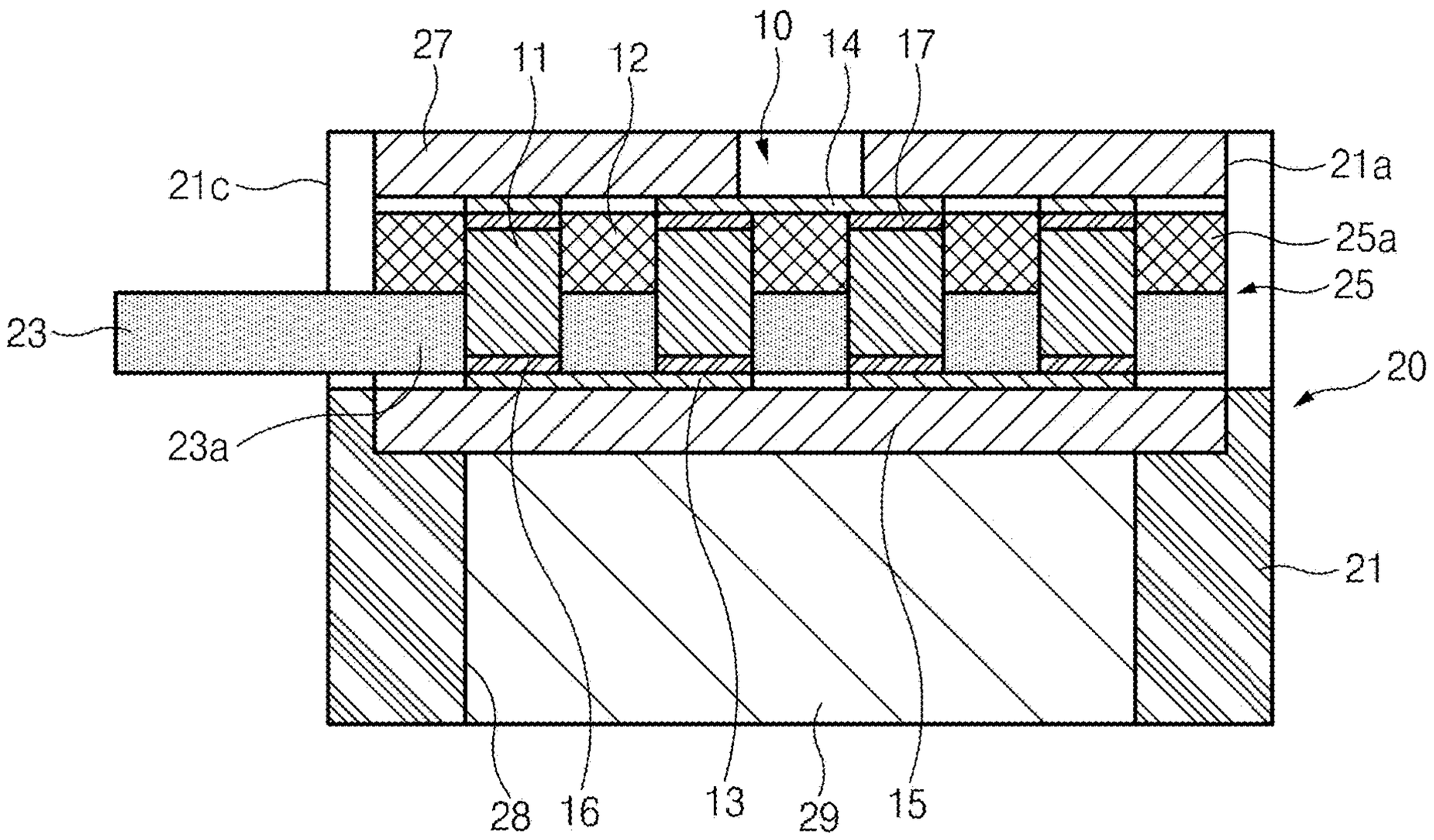


FIG.10

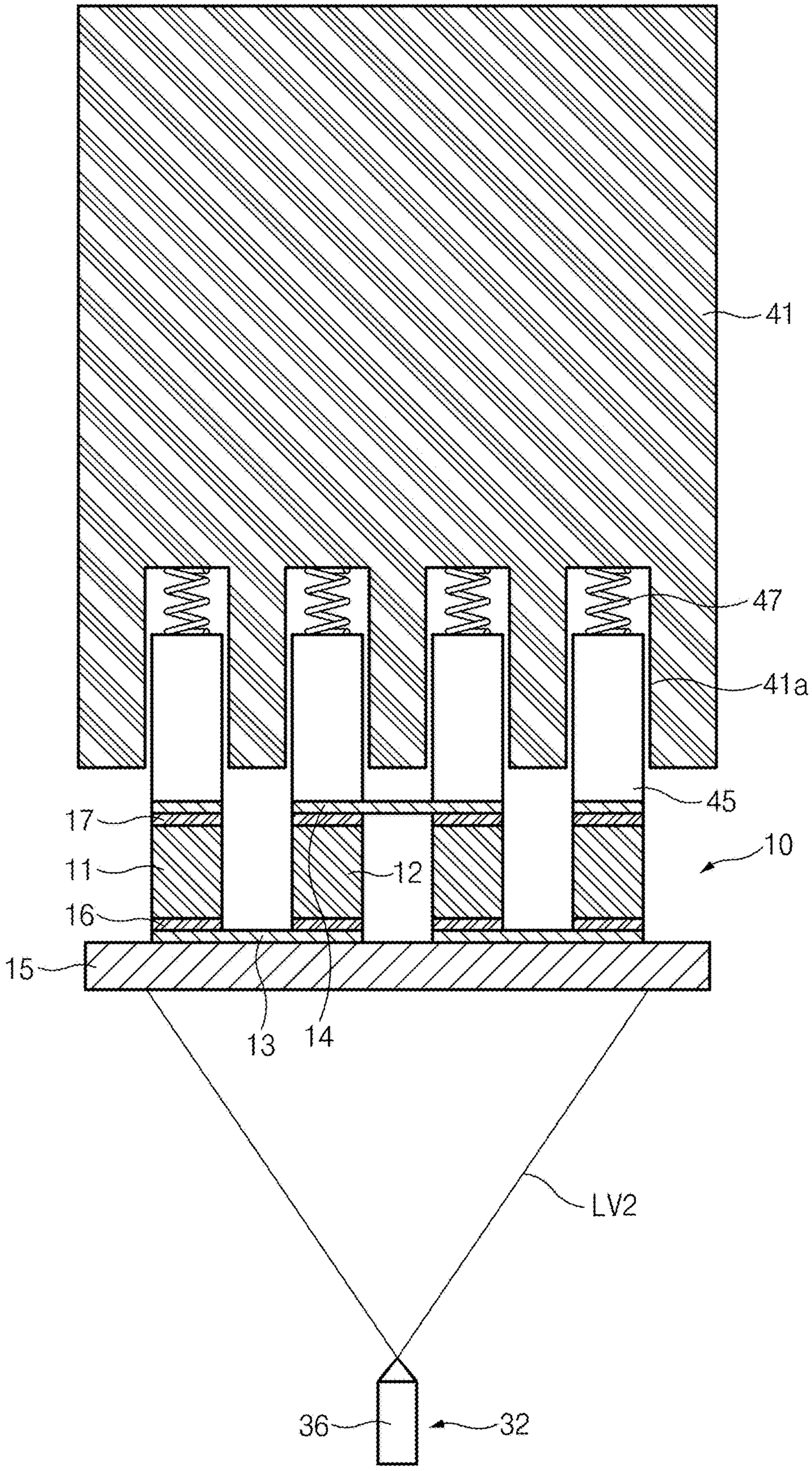


FIG. 11

APPARATUS FOR MANUFACTURING A THERMOELECTRIC MODULE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on and claims priority to Korean Patent Application No. 10-2016-0141155, filed on Oct. 27, 2016, which application is hereby incorporated herein by reference.

TECHNICAL FIELD

The present disclosure relates to an apparatus of manufacturing a thermoelectric module.

BACKGROUND

In general, thermoelectric modules are used in thermoelectric power generation systems based on a Seebeck effect that electromotive force is generated using the difference in temperature between both surfaces of the thermoelectric modules.

When thermoelectric generation is performed by the thermoelectric module, as the difference in temperature between a heat absorption part and a heat radiation part is greatly maintained, the quantity of power generated through the thermoelectric generation may be increased. In this case, a heat transfer rate from a heat source to the thermoelectric module greatly influences the quantity of power generated from the thermoelectric generation.

In the thermoelectric module, a plurality of thermoelectric pellets having mutually different polarities (N type semiconductor and P type semiconductor) are alternately aligned with each other, and electrically connected with each other in series by electrodes, and an insulating substrate may be attached to each electrode.

The electrodes include a first electrode, which receives high-temperature heat, corresponding to the heat absorber of the thermoelectric module, and a second electrode, which receives low-temperature heat, corresponding to the heat radiation part of the thermoelectric module. The first and second electrodes are bonded to the thermoelectric pellets, respectively, by adhesives having conductivity. However, since the first and second electrodes require mutually different use temperatures, the first electrode is bonded to the thermoelectric pellet using a first adhesive having a higher melting point, and the second electrode is bonded to the thermoelectric pellet using a second adhesive having a lower melting point.

In a conventional thermoelectric module manufacturing apparatus to manufacture the thermoelectric module, first electrodes are bonded to the thermoelectric module using the first adhesive under a higher-temperature atmosphere, and then second electrodes are bonded to the thermoelectric module using the second adhesive under a lower-temperature atmosphere.

According to the conventional thermoelectric module, the surface of the thermoelectric pellet, to which the second electrode is bonded, is oxidized due to the higher-temperature atmosphere made when the first electrode is bonded to the thermoelectric pellet. As a result, according to the conventional thermoelectric module, the wettability for the bonding of the second electrode may be adversely influenced, and electric conductivity and thermal conductivity may be degraded, and the performance or the durability of the thermoelectric module may be degraded.

In addition, according to the conventional thermoelectric module manufacturing apparatus, two bonding processes are required for the electrodes. Accordingly, the productivity of the thermoelectric module may be lowered.

SUMMARY

The present disclosure has been made to solve the above-mentioned problems occurring in the prior art while advantages achieved by the prior art are maintained intact.

An aspect of the present disclosure provides an apparatus of manufacturing a thermoelectric module, which has an improved structure to prevent a thermoelectric pellet from being oxidized when a bonding process for electrodes is performed.

In addition, an aspect of the present disclosure provides an apparatus of manufacturing a thermoelectric module, which has an improved structure to bond thermoelectric pellets to electrodes through one bonding process.

The technical problems to be solved by the present disclosure are not limited to the aforementioned problems, and any other technical problems not mentioned herein will be clearly understood from the following description by those skilled in the art to which the present disclosure pertains.

According to an aspect of the present disclosure, an apparatus for manufacturing a thermoelectric module may include thermoelectric pellets, first electrodes that correspond to surfaces of the thermoelectric pellets, second electrodes that correspond to opposite surfaces of the thermoelectric pellets, and an insulating substrate that insulates the first electrodes from each other. The apparatus may include a fixing unit including a fixing tray to which the thermoelectric module is fixed and the first die including a first heating member that heats a first adhesive layer, which is interposed between the surfaces of the thermoelectric pellets and the first electrodes. The fixing tray is mounted on the first die such that the insulating substrate faces the first heating member. A second die includes a second heating member that heats a second adhesive layer, which is interposed between the opposite surfaces of the thermoelectric pellets and the second electrodes. The second die faces the second electrodes. A transfer unit transfers at least one of the first die and the second die to adjust a distance between the first die and the second die.

Preferably, the first die may include a mounting groove, in which the fixing tray is mounted, and a guide hole defined to communicate the first heating member with the mounting groove. The first heating member may be mounted corresponding to the insulating substrate exposed to an outside through the guide hole.

Preferably, the first heating member may be a laser head that heats the first adhesive layer by irradiating a laser beam toward the insulating substrate.

Preferably, the fixing tray may include an insertion hole bored to communicate the insulating substrate with the first heating member, and a transmissive window which is inserted into the insertion hole to support the insulating substrate, and includes a material for transmitting the laser beam.

Preferably, the transfer unit may include at least one cylinder body fixed to one of the first die and the second die, and at least one cylinder rod fixed to a remaining one of the first die and the second die and reciprocally transferred by the at least one cylinder body.

Preferably, the fixing unit may further include a guide member including a plurality of guide ribs extending while

passing through a space between the thermoelectric pellets and are detachably mounted in the fixing tray.

Preferably, the guide member may include a first guide member including a plurality of first guide ribs extending while passing through the space between the thermoelectric pellets in one direction, and a second guide member including a plurality of second guide ribs extending while passing through the space between the thermoelectric pellets in another direction which forms a predetermined angle with the one direction.

Preferably, the fixing tray may further include a plurality of rib grooves into which the guide ribs are inserted, respectively.

Preferably, the guide member may be separated from the fixing tray when the first and second adhesive layers are heated.

Preferably, the second heating member may include a plurality of heaters provided to face one of the second electrodes and to heat the second adhesive layer, and each of the heaters may press and make contact with the one of the second electrodes by the transfer unit.

Preferably, the second heating member may further include a plurality of elastic members which elastically press one of the heaters toward the one of the second electrodes.

Preferably, the second heating member may further include a pressing block including a plurality of heater insertion grooves which are formed while being spaced apart from each other by a mounting distance between the thermoelectric pellets, each elastic member may be securely mounted in an inner lateral side of one of the heater insertion grooves, and each heater may be inserted into the one of the heater insertion grooves such that the heater is elastically supported by the elastic member.

Preferably, the first heating member may be provided to transfer heat corresponding to a melting point of the first adhesive layer to the first adhesive layer through the insulating substrate and the first electrode, and the second heating member may be provided to transfer heat corresponding to a melting point of the second adhesive layer to the second adhesive layer through the second electrode.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present disclosure will be more apparent from the following detailed description taken in conjunction with the accompanying drawings:

FIG. **1** is a front view illustrating an apparatus of manufacturing a thermoelectric module, according to an exemplary embodiment of the present disclosure;

FIG. **2** is a front view illustrating the thermoelectric module;

FIG. **3** is a sectional view illustrating one example of a fixing unit of FIG. **1**;

FIG. **4** is an exploded perspective view illustrating the apparatus of manufacturing the thermoelectric module of FIG. **1**;

FIG. **5** is an assembled perspective view illustrating the apparatus of manufacturing the thermoelectric module of FIG. **1**;

FIG. **6** is a front view illustrating the location relationship between the heating members and the thermoelectric module of FIG. **1**;

FIG. **7** is an assembled perspective view illustrating the thermoelectric module pressed by a second die in the apparatus of manufacturing the thermoelectric module of FIG. **1**;

FIG. **8** is a view illustrating a method of bonding thermoelectric pellets to an electrode using heating members illustrated in FIG. **4**;

FIG. **9** is a view illustrating that the electrode compensates for the step difference between the thermoelectric pellets of FIG. **2**;

FIG. **10** is a sectional view illustrating the fixing unit of FIG. **1**, according to another embodiment of the present disclosure; and

FIG. **11** is a view illustrating another method of bonding thermoelectric pellets to an electrode using the heating members illustrated in FIG. **4**.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

Terms and words used in the specification and the claims shall not be interpreted as commonly-used dictionary meanings, but shall be interpreted as to be relevant to the technical scope of the invention based on the fact that the inventor may properly define the concept of the terms to explain the invention in best ways. Accordingly, the embodiments and the configurations depicted in the drawings are illustrative purposes only and do not represent all technical scopes of the embodiments, so it should be understood that various equivalents and modifications may exist at the time point of filing this application.

The size of each of elements and the size of a specific part of the element, which are shown in accompanying drawings, may be exaggerated, omitted or schematically drawn for the purpose of convenience or clarity. In addition, the size of elements does not utterly reflect an actual size. In the following description, detailed descriptions of functions or configurations of well-known elements will be ruled out in order not to unnecessarily obscure the gist of the present disclosure.

FIG. **1** is a front view illustrating an apparatus **1** for manufacturing a thermoelectric module according to an exemplary embodiment of the present disclosure.

Referring to FIG. **1**, the apparatus **1** for manufacturing the thermoelectric module according to an exemplary embodiment of the present disclosure (hereinafter referred to as "thermoelectric module manufacturing apparatus") includes a fixing unit **20**, which fixes a thermoelectric module **10** thereto, a first die **30**, on which thermoelectric pellets **11** and **12** may be bonded to a first electrode **13**, a second die **40**, on which thermoelectric pellets **11** and **12** may be bonded to a second electrode **14**, and a transfer unit **50** which adjusts the distance between the first die **30** and the second die **40**.

FIG. **2** is a front view illustrating the thermoelectric module.

As illustrated in FIG. **2**, the thermoelectric module **10** may include a plurality of thermoelectric pellets **11**, a plurality of thermoelectric pellets **12**, first electrodes **13** which correspond to one surfaces of the thermoelectric pellets **11** and **12**, second electrodes **14** which correspond to opposite surfaces of the thermoelectric pellets **11** and **12**, a first adhesive layer **16** interposed between the thermoelectric pellets **11** and **12** and the first electrodes **13**, a second adhesive layer **17** interposed between the thermoelectric pellets **11** and **12** and the second electrodes **14**, and an insulating substrate **15** which insulates the first electrodes **13** from each other.

As illustrated in FIG. **2**, the thermoelectric pellets **11** and **12** include a first thermoelectric pellet **11** and a second thermoelectric pellet **12** having mutually opposite polarities. For example, when the first thermoelectric pellet **11** is an N

type semiconductor, the second thermoelectric pellet **12** is a P type semiconductor. When the first thermoelectric pellet **11** is a P type semiconductor, the second thermoelectric pellet **12** is an N type semiconductor. First thermoelectric pellets **11** are alternately aligned with second thermoelectric pellets **12** as illustrated in FIG. **11**.

As illustrated in FIG. **2**, the first and second thermoelectric pellets **11** and **12** have first bonding surfaces **11***a* and **12***a*, which are one surfaces corresponding to any one of a heat absorption part and a heat radiation part of the thermoelectric module **10**, and second bonding surfaces **11***b* and **12***b* which are opposite surfaces corresponding to a remaining one of the heat absorption part and the heat radiation part of the thermoelectric module **10**. Hereinafter, the present disclosure will be described in that the first bonding surfaces **11***a* and **12***a* correspond to the heat absorption part of the thermoelectric module **10**, and the second bonding surfaces **11***b* and **12***b* correspond to the heat radiation part of the thermoelectric module **10**.

Each of the first electrodes **13** is provided to electrically connect the first bonding surfaces **11***a* and **12***a* of one pair of the first and second thermoelectric pellets **11** and **12**, which are adjacent to each other, with each other. To this end, as illustrated in FIG. **2**, each first electrode **13** is provided to make contact with both first bonding surfaces **11***a* and **12***a* of the pair of first and thermoelectric pellets **11** and **12** adjacent to each other.

Each of the second electrodes **14** is provided to electrically connect the second bonding surfaces **11***b* and **12***b* of one pair of first and thermoelectric pellets **11** and **12**, which are adjacent to each other, to each other. To this end, as illustrated in FIG. **2**, each of the second electrodes **14** is provided to make contact with both second bonding surfaces **11***b* and **12***b* of the pair of first and thermoelectric pellets **11** and **12** are adjacent to each other. The second electrode **14** is provided such that a connection part **14***a* of the second electrode **14** is interposed between the first and second thermoelectric pellets **11** and **12** and bent when the second electrode **14** is pressed by a heater **45** to be described later as illustrated in FIG. **9**. For example, the first electrodes **14** may have the form of a foil or may have the thickness of 1 mm or less.

As illustrated in FIG. **2**, the first adhesive layer **16** is interposed between the first bonding surfaces **11***a* and **12***a* of the first and second thermoelectric pellet **11** and **12** and one surface of the first electrode **13**. For example, the first adhesive layer **16** may be formed by coating the first bonding surfaces **11***a* and **12***a* of the first and second thermoelectric pellet **11** and **12** or the one surface of the first electrode **13** with a first adhesive. The first adhesive preferably includes a material having a higher melting point because a higher temperature is actually applied to the heat absorption part of the thermoelectric module **10**. For example, the first adhesive may be a silver (Ag)-based brazing filler.

As illustrate in FIG. **2**, the second adhesive layer **17** is interposed between the second bonding surfaces **11***b* and **12***b* of the first and second thermoelectric pellets **11** and **12** and one surface of the second electrode **14**. For example, the second adhesive layer **17** may be formed by coating the second bonding surfaces **11***b* and **12***b* of the first and second thermoelectric pellet **11** and **12**, or the one surface of the second electrode **14** with a second adhesive. The second adhesive preferably includes a material having a lower melting point because a lower temperature is actually applied to the heat radiation part of the thermoelectric module **10**. For example, the second adhesive may be a silver (Ag)-based thermal paste.

As illustrated in FIG. **2**, the insulating substrate **15** is provided to make contact with an opposite surface of the first electrode **13**. The insulating substrate **15** is formed of an insulating material for insulating the first electrode **13** from the outside. For example, the insulating substrate **15** may be formed of alumina or other ceramic materials having an insulating property.

Meanwhile, although the second electrode **14** may be preferably subject to insulation treatment such that the second electrode **14** may be insulated from the outside, the present disclosure is not limited thereto. For example, when the thermoelectric module **10** is actually used, an insulating material having high thermal conductivity is applied to the second electrode **14** to prevent the second electrode **14** from being shorted. The insulating material having the high thermal conductivity may be a silicon-based thermally conductive paste or a silicon-based thermally conductive sheet. In particular, the silicon-based thermally conductive paste may be a material containing ceramic-based fillers, such as alumina and boron nitride, having an electrically insulating property and high thermal conductivity.

FIG. **3** is a sectional view illustrating one example of the fixing unit **20** illustrated in FIG. **1**. FIG. **4** is an exploded perspective view illustrating the thermoelectric module manufacturing apparatus **1** illustrated in FIG. **1**. FIG. **5** is an assembled perspective view illustrating the thermoelectric module manufacturing apparatus **1** illustrated in FIG. **1**.

The fixing unit **20** is provided to mount the thermoelectric module **10** on the first die **30**. For example, as illustrated in FIG. **3**, the fixing unit **20** may include a fixing tray **21**, to which the thermoelectric module **10** is fixed, guide members **23** and **25** which align the thermoelectric pellets **11** and **12** in a preset arrangement form, and a fixing cover **27** which covers the thermoelectric module **10** and the guide members **23** and **25**.

As illustrated in FIGS. **3** and **4**, the fixing tray **21** may include a fixing groove **21***a*, a plurality of communication holes **21***b*, a plurality of first rib insertion grooves **21***c*, a plurality of second rib insertion grooves **21***d*.

As illustrated in FIG. **3**, the fixing groove **21***a* is formed by opening a top surface of the fixing tray **21** corresponding to the thermoelectric module **10**. The thermoelectric module **10** is inserted into the fixing groove **21***a* and fixed into the fixing groove **21***a* such that the insulating substrate **15** is securely mounted by inner lateral sides of the fixing groove **21***a*. In other words, the thermoelectric module **10** is fixed into the fixing groove **21***a* such that the second electrode **14** is directed toward an opening of the fixing groove **21***a*.

As illustrated in FIG. **3**, each communication hole **21***b* communicates with the fixing groove **21***a* and is bored through a bottom surface of the fixing tray **21** corresponding to any one of the thermoelectric pellets **11** and **12**. The communication holes **21***b* allow the fixing groove **21***a* to communicate with guide holes **33** and **35** formed in the first die **30**, which will be described later. The thermoelectric module **10** may be irradiated with a laser beam (LV) which is radiated from a first heating member **32** to be described later and sequentially passes through the guide holes **33** and **35** and the communication hole **21***b*.

As illustrated in FIG. **4**, the first rib insertion grooves **21***c* are formed in one sidewall of the fixing tray **21** while extending in one direction and are spaced apart from each other by a distance between the thermoelectric pellets **11** and

12. First guide ribs **23***a* of a first guide member **23** to be described later may be inserted into the first rib insertion grooves **21***c*, respectively.

As illustrated in FIG. **4**, the second rib insertion grooves **21***d* are formed in another sidewall of the fixing tray **21**, which is performed perpendicularly to the one sidewall of the fixing tray **21**, and are spaced apart from each other by a distance between the thermoelectric pellets **11** and **12**. Second guide ribs **25***a* of a second guide member **25** to be described later may be inserted into the second rib insertion grooves **21***d*, respectively.

As illustrated in FIG. **4**, the guide members **23** and **25** may include the first guide member **23** and the second guide member **25**.

As illustrated in FIG. **7**, the first guide member **23** may have the first guide ribs **23***a*, each of which extends through the space between one pair of thermoelectric pellets **11** and **12**, which are adjacent to each other, in one direction. As illustrated in FIGS. **3** and **4**, the first guide member **23** may be detachably mounted in the fixing tray **21** such that each first guide rib **23***a* is inserted into any one of the first insertion grooves **21***c* of the fixing tray **21** while extending through the space between the thermoelectric pellets **11** and **12**, which are adjacent to each other, in the direction. Although it is preferred that the first guide member **23** is provided such that each first guide rib **23***a* is securely mounted on the first electrode **13** or the insulating substrate **15** as illustrated in FIG. **3**, the present disclosure is not limited thereto.

As illustrated in FIG. **7**, the second guide member **25** may have the second guide ribs **25***a*, each of which extends through the space between one pair of thermoelectric pellets **11** and **12**, which are adjacent to each other, in a direction perpendicular to the one direction. As illustrated in FIGS. **3** and **4**, the second guide member **25** may be detachably mounted in the fixing tray **21** such that each second guide rib **25***a* is inserted into one second insertion groove **21***d* of the fixing tray **21** while extending through the space between the thermoelectric pellets **11** and **12**, which are adjacent to each other, in another direction. Although it is preferred that the second guide ribs **25***a* of the second guide member **25** are securely mounted on the first guide ribs **23***a*, respectively, as illustrated in FIG. **3**, the present disclosure is not limited thereto.

The first and second guide members **23** and **25** support the first and second thermoelectric pellets **11** and **12** by the guide ribs **23***a* and **25***a* in one direction and another direction, respectively. Accordingly, the first and second guide members **23** and **25** may align the thermoelectric pellets **11** and **12** in a preset arrangement form.

As illustrated in FIG. **3**, the fixing cover **27** is formed in a shape corresponding to the shape of the fixing groove **21***a*. The fixing cover **27** is detachably inserted into the fixing groove **21***a* to cover the guide ribs **23***a* and **25***a* and the thermoelectric module **10**.

FIG. **6** is a front view to explain the location relationship between heating members and the thermoelectric module **10** of FIG. **1**.

The first die **30** is provided such that the first bonding surfaces **11***a* and **12***a* of the thermoelectric pellets **11** and **12** may be bonded to the first electrode **13** through the first adhesive layer **16**. To this end, the first die **30** may include a first guide hole **33**, a support block **31**, and a first heating member **32**.

As illustrated in FIG. **1**, the first guide hole **33** is formed through the first die **30** such that the first guide hole **33** corresponds to the communication holes **21***b* formed in the fixing tray **21**. Although the first guide hole **33** preferably has a taper shape in which the diameter of the first guide hole **33** is gradually reduced toward the fixing tray **21**, the present disclosure is not limited thereto.

As illustrated in FIG. **1**, the support block **31** is mounted on one surface of the first die **30**. The support block **31** may include a mounting groove **34** and a second guide hole **35**.

As illustrated in FIG. **4**, the mounting groove **34** is formed in one surface of the support block **31** such that the mounting groove **34** faces a pressing block **41** to be described later. Preferably, the mounting groove **34** has a shape corresponding to the shape of the fixing tray **21** to support the fixing tray **21**. As illustrated in FIG. **5**, the fixing tray **21** is mounted in the mounting groove **34** such that the second electrodes **14** are directed toward the pressing block **41**.

As illustrated in FIG. **1**, the second guide hole **35** is formed through the support block **31** corresponding to the communication holes **21***b* of the fixing tray **21** such that the second guide hole **35** communicates with each of the mounting groove **34** and the first guide hole **33**.

As illustrated in FIG. **6**, the first heating member **32** is provided to face the insulating substrate **15**. For example, the first heating member **32** may be provided inside or outside the guide hole **33** or **35** such that the first heating member **32** corresponds to the communication holes **21***b*. Preferably, the first heating member **32** is provided to transfer heat corresponding to the melting point of the first adhesive layer **16** to the first adhesive layer **16** through the insulating substrate **15** and the first electrode **13**. In other words, when the first adhesive is the Ag-based brazing filler, the first heating member **32** is provided to raise the temperature of the first adhesive layer **16** to 450° C. or more. For example, the first heating member **32** may be a laser head **36** which may emit a laser beam LV. The laser head **36** may be a laser nozzle or a laser scanner. The laser head **36** may irradiate the laser beam LV onto the insulating substrate **15** corresponding to the thermoelectric pellets **11** and **12** as illustrated in FIG. **8**.

The second die **40** is provided such that the second bonding surfaces **11***b* and **12***b* of the thermoelectric pellets **11** and **12** may be bonded to the second electrode **14** through the second adhesive layer **17**. To this end, the second die **40** may include the pressing block **41**, a second heating member **43**, and an elastic member **47**.

As illustrated in FIG. **5**, the pressing block **41** is mounted on one surface of the second die **40** to face the thermoelectric module **10** fixed to the fixing tray **21**. As illustrated in FIG. **6**, the pressing block **41** includes a plurality of heater insertion grooves **41***a* recessed corresponding the thermoelectric pellets **11** and **12**.

Preferably, the second heating member **43** is provided to transfer heat corresponding to the melting point of the second adhesive layer **17** to the second adhesive layer **17** through the second electrode **14**. In other words, when the second adhesive is the Ag-based thermal paste, the second heating member **42** is provided to raise the temperature of the second adhesive layer **17** to less than 200° C. For example, the second heating member **43** may include a plurality of heaters **45** as illustrated in FIG. **6**. The heaters **45** may be formed in the shape of a stick having a sectional area corresponding to those of the thermoelectric pellets **11** and **12**. Each heater **45** may be formed of a metallic material having higher thermal conductivity, and a heating line (not shown), which emits heat by power supplied thereto from the outside, may be buried in the heater **45**. As illustrated in FIG. **6**, each heater **45** may be inserted into and mounted in

any one of the heater insertion grooves **41***a* such that the heater **45** is supported by the elastic member **47**.

As illustrated in FIG. **6**, the elastic member **47** may be securely mounted on an inner surface of the heater insertion groove **41***a* such that the elastic member **47** is interposed between the inner surface of the heater insertion groove **41***a* and the heater **45**. The elastic member **47** is provided to elastically press the heater **45**, which is inserted into the heater insertion groove **41***a*, toward the thermoelectric pellets **11** and **12**. For example, the elastic member **47** may be a compressive spring as illustrated in FIG. **8**.

The transfer unit **50** is provided to adjust the distance between the first die **30** and the second die **40**. The transfer unit **50** preferably includes at least one cylinder. For example, as illustrated in FIG. **1**, the transfer unit **50** may include a cylinder body **52** fixed to the first die **30** and a cylinder rod **54** fixed to the second die **40** and reciprocally transferred by the cylinder body **52**. The transfer unit **50** may reciprocally transfer the second die **40** such that the second die **40** approaches the first die **30** or is away from the first die **30**.

FIG. **7** is an assembled perspective view illustrating the thermoelectric module **10** pressed by the second die **40** in the thermoelectric module manufacturing apparatus **1** of FIG. **1**. FIG. **8** is a view illustrating a method of bonding the thermoelectric pellets **11** and **12** to the electrode using the heating member of FIG. **4**. FIG. **9** is a view illustrating that the electrode **13** compensates for the step difference between the thermoelectric pellets **11** and **12** of FIG. **2**.

Hereinafter, a method of manufacturing the thermoelectric module **10** using the thermoelectric module manufacturing apparatus **1** will be described with reference to accompanying drawings.

First, as illustrated in FIG. **3**, after the thermoelectric module **10** is fixed into the fixing groove **21***a* of the fixing tray **21**, the thermoelectric pellets **11** and **12** are aligned using the first and second guide members **23** and **25** and the fixing cover **27**. In the operation in which the above thermoelectric module **10** is fixed into the fixing groove **21***a*, the first and second adhesive layers **16** and **17** are only interposed between the first and second bonding surfaces **11***a* and **12***a* and **11***b* and **12***b* of the first and second thermoelectric pellets **11** and **12** and the first and second electrodes **13** and **14**. In this state, the first and second bonding surfaces **11***a* and **12***a*, and **11***b* and **12***b* of the first and second thermoelectric pellets **11** and **12** are not bonded to the first and second electrodes **13** and **14**.

As illustrated in FIG. **5**, the fixing tray **21** having the thermoelectric module **10** fixed thereto is mounted in a preset position of the mounting groove **34**.

Thereafter, as illustrated in FIG. **7**, the first and second guide members **23** and **25** and the fixing cover **27** are separated from the fixing tray **21**.

Next, as illustrated in FIGS. **7** and **8**, the second die **40** is transferred to the first die **30** by the transfer unit **50** such that the second electrodes **14** are pressed by the heaters **45**.

Subsequently, as illustrated in FIG. **8**, the laser head **36** is actuated to irradiate the laser beam LV to the insulating substrate **15**, and the heaters **45** are actuated to apply heat to the second electrodes **14**.

Then, as illustrated in FIG. **8**, the laser beam LV is irradiated to the first adhesive layer **16** after being transmitted through the insulating substrate **15** and the first electrode **13**. Accordingly, the first adhesive layer **16** is heated to the melting point by the laser beam LV and melted. Thus, the first bonding surfaces **11***a* and **12***a* of the thermoelectric pellets **11** and **12** are bonded to the first electrode **13** by the melted first adhesive layer **16**.

As illustrated in FIG. **8**, each of the heaters **45** heats the second adhesive layer **17** through the second electrode **14**. Accordingly, the second adhesive layer **17** is heated to the melting point thereof by the heater **45** and melted. Thus, the second bonding surfaces **11***b* and **12***b* of the thermoelectric pellets **11** and **12** are bonded to the second electrode **14** by the melted second adhesive layer **17**.

The heaters **45** may elastically press the thermoelectric pellets **11** and **12**, the first and second electrodes **13** and **14**, and the first and second the adhesive layers **16** and **17** toward the insulating substrate **15** by driving force transferred from the transfer unit **50** and elastic force transferred from the elastic members **47**. Accordingly, bonding force may be improved at the interface between the bonding surfaces **11***a*, **11***b*, **12***a*, and **12***b* of the thermoelectric pellets **11** and **12**, and the electrodes **13** and **14**.

Meanwhile, as described above, the second electrodes **14** have preset shapes or preset thicknesses such that the connection parts **14***a* may be bent by the force applied thereto from the heaters **45**. Accordingly, as illustrated in FIG. **9**, when the step difference is made between the thermoelectric pellets **11** and **12** due to the process tolerance, the connection parts **14***a* of the second electrodes **14** are bent by the height H of the step difference. Accordingly, bonding force at the interfaces between the bonding surfaces **11***a*, **11***b*, **12***a*, and **12***b* of the thermoelectric pellets **11** and **12** and the electrodes **13** and **14** may be prevented from being degraded due to the step difference between the thermoelectric pellets **11** and **12**.

Next, after the second die **40** is transferred using the transfer unit **50** such that the heaters **45** are spaced apart from the second electrodes **14**, the thermoelectric module **10** having the thermoelectric pellets **11** and **12** and the electrodes **13** and **14**, which are completely bonded to each other, may be separated from the fixing tray **21**.

As described above, according to the thermoelectric module manufacturing apparatus **1**, the first adhesive layer **16** having a higher melting point is heated by using the laser beam LV which may locally apply heat. Simultaneously, the second adhesive layer **17** having a lower melting point is heated by using the heaters **45** which may elastically press the thermoelectric pellets **11** and **12** and the electrodes **13** and **14**. Accordingly, the thermoelectric module manufacturing apparatus **1** prevents the second bonding surfaces **11***b* and **12***b* of the thermoelectric pellets **11** and **12** corresponding to the heat radiation part of the thermoelectric module **10** from being oxidized due to the high-temperature heat radiated when the first adhesive layer **16** is heated, thereby stably ensuring the wettability for the bonding of the second electrodes **14** and improving the performance and the durability of the thermoelectric module **10**.

In addition, according to the thermoelectric module manufacturing apparatus **1**, predetermined pressure is applied between the thermoelectric pellets **11** and **12** and the electrodes **13** and **14** when the thermoelectric pellets **11** and **12** are bonded to the electrodes **13** and **14**. Accordingly, the bonding force at the interface between the thermoelectric pellets **11** and **12** and the electrodes **13** and **14** may be improved.

In addition, according to the thermoelectric module manufacturing apparatus **1**, in the state that the thermoelectric module **10** is fixed to a preset position of the fixing tray **21**, the thermoelectric pellets **11** and **12** may be bonded to

the electrodes **13** and **14**. Accordingly, the performance and the durability of the thermoelectric module **10** may be more improved.

In addition, according to the thermoelectric module manufacturing apparatus **1**, the thermoelectric pellets **11** and **12** are bonded to the first electrode **13** corresponding to the heat absorption part of the thermoelectric module **10** while being bonded to the second electrode **14** corresponding to the heat radiation part of the thermoelectric module **10**. Accordingly, the productivity of the thermoelectric module **10** may be improved as compared with that of the related art in which the bonding processes are separately performed.

Meanwhile, although the thermoelectric pellets **11** and **12** are bonded to the first electrodes **13** using the laser beam LV, and the thermoelectric pellets **11** and **12** are bonded to the second electrodes **14** using the heaters **45** in the thermoelectric module manufacturing apparatus **1**, the present disclosure is not limited thereto. In other words, the first heating member **32** is provided to include a pressing block, a heater, or an elastic member similarly to the second heating member **43**, and the thermoelectric pellets **11** and **12** may be bonded to the first electrodes **13** using heaters.

FIG. **10** is a sectional view illustrating the fixing unit of FIG. **1**, according to another embodiment.

Although the fixing unit **20** includes a plurality of communication holes **21***b* communicating with the guide holes **33** and **35** such that the insulating substrate **15** is irradiated with the laser beam LV emitted from the laser head **36**, the present disclosure is not limited thereto. For example, as illustrated in FIG. **10**, the fixing unit **20** may include an insertion hole **28** bored corresponding to the thermoelectric pellets **11** and **12** instead of the communication holes **21***b* and a transmissive window **29** inserted into the insertion hole **28** such that the transmissive window **29** may support the thermoelectric module **10** fixed into the fixing groove **21***a*.

As illustrated in FIG. **10**, although the insertion hole **28** is formed through the bottom surface of the fixing tray **21** such that the insertion hole **28** faces the whole thermoelectric pellets **11** and **12** with the insulating substrate **15** interposed therebetween, the present disclosure is not limited thereto.

As illustrated in FIG. **10**, the transmissive window **29** has the shape corresponding to that of the insertion hole **28** such that the transmissive window **29** is fitted into the insertion hole **28**. For example, the transmissive window **29** may be formed of a glass material allowing the laser beam to pass therethrough.

FIG. **11** is a view illustrating another method of bonding thermoelectric pellets and electrodes using the heating members illustrated in FIG. **4**.

Although the above description has been made in that the laser head **36** irradiates the laser beam to the first adhesive layer **16** through each communication hole **21***b*, the present disclosure is not limited thereto.

For example, as illustrated in FIG. **10**, the laser head **36** may be provided to irradiate a laser beam LV**2** having a beam spot with a diameter corresponding to the insulating substrate **15** to the insulating substrate **15** through the transmissive window **29**. Then, the insulating substrate **15** is heated by the laser beam LV**2**, and the first adhesive layers are heated by receiving the heat from the insulating substrate **15** through the first electrodes. Accordingly, the thermoelectric pellets **11** and **12** are simultaneously bonded to the first electrodes **13** by the first adhesive layers **16**, thereby reducing time taken to bond the thermoelectric pellets **11** and **12** to the first electrodes **13**.

As described above, according to the present disclosure, the thermoelectric module manufacturing apparatus may simultaneously perform a process of bonding the heat absorption part of the thermoelectric module to a relevant electrode and a process of bonding the heat radiation part of the thermoelectric module to a relevant electrode. Therefore, according to the present disclosure, the bonding surface of the thermoelectric pellet may be prevented from being oxidized, and the wettability for the bonding of the electrodes may be stably ensured. According to the present disclosure, the performance and the durability of the thermoelectric module may be improved, and the productivity of the thermoelectric module may be improved.

Hereinabove, although the present disclosure has been described with reference to exemplary embodiments and the accompanying drawings, the present disclosure is not limited thereto, but may be variously modified and altered by those skilled in the art to which the present disclosure pertains without departing from the spirit and scope of the present disclosure claimed in the following claims.

What is claimed is:

1. An apparatus for manufacturing a thermoelectric module which comprises thermoelectric pellets, first electrodes corresponding to first surfaces of the thermoelectric pellets, second electrodes corresponding to opposite second surfaces of the thermoelectric pellets, and an insulating substrate insulating the first electrodes from each other, the apparatus comprising:

a fixing tray to which the thermoelectric module can be fixed;

a guide member detachably mounted in the fixing tray so as to align the thermoelectric pellets in a preset arrangement form;

a first die comprising a first heating member configured to heat a first adhesive layer, which is interposed between the first surfaces of the thermoelectric pellets and the first electrodes, the fixing tray being mounted on the first die such that the insulating substrate faces the first heating member;

a second die comprising a second heating member configured to heat a second adhesive layer, which is interposed between the opposite second surfaces of the thermoelectric pellets and the second electrodes, the second die facing the second electrodes; and

a transfer unit configured to transfer the first die or the second die to adjust a distance between the first die and the second die.

2. The apparatus of claim **1**, wherein the transfer unit comprises:

a cylinder body fixed to one of the first die or the second die; and

a cylinder rod fixed to the other of the first die and the second die and reciprocally transferred by the cylinder body.

3. The apparatus of claim **1**, wherein the second heating member comprises a plurality of heaters each of which is provided to face one of the second electrodes so as to heat the second adhesive layer, and wherein each of the heaters presses the one of the second electrodes as the transfer unit transfers the first die or the second die.

4. The apparatus of claim **3**, wherein the second heating member further comprises a plurality of elastic members each of which elastically presses one of the heaters toward the one of the second electrodes.

5. The apparatus of claim **4**, wherein the second heating member further comprises a pressing block comprising a plurality of heater insertion grooves that are formed while

being spaced apart from each other by a mounting distance between the thermoelectric pellets;

wherein each elastic member is securely mounted in an inner lateral side of one of the heater insertion grooves; and

wherein each heater is inserted into the one of the heater insertion grooves.

6. The apparatus of claim **1**, wherein the first heating member is provided to transfer heat corresponding to a melting point of the first adhesive layer to the first adhesive layer through the insulating substrate and the first electrodes; and

wherein the second heating member is provided to transfer heat corresponding to a melting point of the second adhesive layer to the second adhesive layer through the second electrodes.

7. An apparatus for manufacturing a thermoelectric module which comprises thermoelectric pellets, first electrodes corresponding to first surfaces of the thermoelectric pellets, second electrodes corresponding to opposite second surfaces of the thermoelectric pellets, and an insulating substrate insulating the first electrodes from each other, the apparatus comprising:

a fixing unit comprising a fixing tray to which the thermoelectric module can be fixed and a guide member comprising a plurality of guide ribs extending while passing through a space between the thermoelectric pellets, the guide ribs being detachably mounted in the fixing tray;

a first die comprising a first heating member configured to heat a first adhesive layer, which is interposed between the first surfaces of the thermoelectric pellets and the first electrodes, the fixing tray being mounted on the first die such that the insulating substrate faces the first heating member;

a second die comprising a second heating member configured to heat a second adhesive layer, which is interposed between the opposite second surfaces of the thermoelectric pellets and the second electrodes, the second die facing the second electrodes; and

a transfer unit configured to transfer the first die or the second die to adjust a distance between the first die and the second die.

8. The apparatus of claim **7**, wherein the first die comprises:

a mounting groove, in which the fixing tray is mounted; and

a guide hole defined to communicate the first heating member with the mounting groove, wherein the first heating member is mounted to correspond to the insulating substrate exposed to an outside through the guide hole.

9. The apparatus of claim **8**, wherein the first heating member comprises a laser head configured to heat the first adhesive layer by irradiating a laser beam toward the insulating substrate and, wherein the fixing tray comprises:

an insertion hole bored to communicate the insulating substrate with the first heating member; and

a transmissive window inserted into the insertion hole to support the insulating substrate, the transmissive window formed from a material through which the laser beam can be transmitted.

10. The apparatus of claim **7**, wherein the transfer unit comprises:

a cylinder body fixed to one of the first die or the second die; and

a cylinder rod fixed to the other of the first die and the second die and reciprocally transferred by the cylinder body.

11. The apparatus of claim **7**, wherein the guide member comprises:

a first guide member comprising a plurality of first guide ribs extending while passing through the space between the thermoelectric pellets in one direction; and

a second guide member comprising a plurality of second guide ribs extending while passing through the space between the thermoelectric pellets in another direction that forms a predetermined angle with the one direction.

12. The apparatus of claim **7**, wherein the fixing tray further comprises a plurality of rib grooves into which the guide ribs are inserted, respectively.

13. The apparatus of claim **12**, wherein the guide member is separated from the fixing tray when the first and second adhesive layers are heated.

14. The apparatus of claim **7**, wherein the second heating member comprises a plurality of heaters each of which is provided to face one of the second electrodes so as to heat the second adhesive layer, and wherein each of the heaters presses the one of the second electrodes as the transfer unit transfers the first die or the second die.

15. The apparatus of claim **14**, wherein the second heating member further comprises:

a plurality of elastic members each of which elastically presses one of the heaters toward the one of the second electrodes; and

a pressing block comprising a plurality of heater insertion grooves that are formed while being spaced apart from each other by a mounting distance between the thermoelectric pellets;

wherein each elastic member is securely mounted in an inner lateral side of one of the heater insertion grooves; and

wherein each heater is inserted into the one of the heater insertion grooves.

16. An apparatus for manufacturing a thermoelectric module which comprises thermoelectric pellets, first electrodes corresponding to first surfaces of the thermoelectric pellets, second electrodes corresponding to opposite second surfaces of the thermoelectric pellets, and an insulating substrate insulating the first electrodes from each other, the apparatus comprising:

a fixing tray to which the thermoelectric module can be fixed;

a guide member detachably mounted in the fixing tray so as to align the thermoelectric pellets in a preset arrangement form;

a first die comprising a first heating member configured to heat a first adhesive layer, which is interposed between the first surfaces of the thermoelectric pellets and the first electrodes, the fixing tray being mounted on the first die such that the insulating substrate faces the first heating member, wherein the first die further comprises a mounting groove, in which the fixing tray is mounted, and a guide hole defined to communicate the first heating member with the mounting groove, and wherein the first heating member is mounted to correspond to the insulating substrate exposed to an outside through the guide hole;

a second die comprising a second heating member configured to heat a second adhesive layer, which is interposed between the opposite second surfaces of the

thermoelectric pellets and the second electrodes, the second die facing the second electrodes; and

a transfer unit configured to transfer the first die or the second die to adjust a distance between the first die and the second die.

17. The apparatus of claim **16**, wherein the first heating member comprises a laser head configured to heat the first adhesive layer by irradiating a laser beam toward the insulating substrate.

18. The apparatus of claim **17**, wherein the fixing tray comprises:

an insertion hole bored to communicate the insulating substrate with the first heating member; and

a transmissive window inserted into the insertion hole to support the insulating substrate, the transmissive window formed from a material through which the laser beam can be transmitted.

19. The apparatus of claim **16**, wherein the transfer unit comprises:

a cylinder body fixed to one of the first die or the second die; and

a cylinder rod fixed to the other of the first die and the second die and reciprocally transferred by the cylinder body.

20. The apparatus of claim **16**, wherein the second heating member comprises a plurality of heaters each of which is provided to face one of the second electrodes so as to heat the second adhesive layer, and wherein each of the heaters presses the one of the second electrodes as the transfer unit transfers the first die or the second die.

* * * * *